Photo: ISO

Orchestrating colour – new tools and capabilities

by David McDowell,
NPES/Eastman Kodak

In today's world of colour management[1], we find ourselves in an interesting situation. We have too many options and capabilities, there is no dominant solution that is providing a common direction, and very few users understand the basic principles of colour management.

As a result, user expectations and understanding vary widely and often conflict both with one another and with the capabilities of existing applications.

1) An earlier version of this article appeared in the *IPA Bulletin*

It is easy to see why this situation exists. The standards provide the file formats to enable the exchange of data – but don't regulate exactly what data should be exchanged.

The colour management vendors provide the tools to manage colour but leave it up to the user to decide what to manage and when to manage it. The page composition programmes also leave it up to the user to decide what to do. The picture editing programmes are even more flexible and allow the user complete freedom to edit in any colour space desired.

> **"Colour management gives us tools and capabilities that allow us to be more efficient and to do things that were impossible only a few years ago."**

The closest thing we have to any applied industry systems architects are some of the industry consultants, and each has his or her own agenda.

How is colour management being used today?

CMYK Data Exchange

Within much of the world, CMYK (cyan, magenta, yellow, black) data are still the basic exchange format for graphic arts data. However, colour management is more and more being used to create that CMYK data. Even when colour management is not used in the creation of CMYK data, it is being used to identify the printing conditions for which the CMYK data were intended. The PDF/X-1a file format (defined in ISO 15930-Parts 1 and 3) requires pointers to standard characterization data, to be included as part of the file. The preferred registry

that is identified in the PDF/X standards is the International Color Consortium (ICC) registry at **www.color.org**. Where the expected printing does not match a registered characterized printing condition, a destination profile must be included.

This has placed much more emphasis on the ICC characterization registry and characterized printing condition data that are identified in that registry.

For the first time in the history of our industry, we have a single location to point to where established sets of data that relate CMYK input values to printed colour are identified. Also, for the first time, our data exchange formats require such information.

Because a colour management system that delivers CMYK data typically does not interact with other colour management systems, many of the current colour management issues, while frustrating, do not have an impact on the final CMYK data exchange. The sender still can look at a CMYK proof before committing the data to a printer or publisher.

Exchange of Colour-Managed Data

There is increasing interest in exchanging three-component data, more so in Europe and newspaper applications. Most people casually refer to this as exchanging RGB (red, green, blue) data, forgetting that there are many RGBs from which to choose. Here the relationship between colour management and data exchange is closely coupled.

In September 2002, the first graphic arts data exchange standard that fully enabled the exchange of colour-managed data came into existence. PDF/X-3 (ISO 15930-3:2002 which was updated by ISO 15930-6:2003) represents a major step forward and allows the exchange of fully defined three-component data for graphic arts applications. It requires the use of ICC destination profiles to identify the intended output condition and to define the data conversion between the profile connection space (PCS) and the input code values of the intended printing device. It also makes provision for source profiles to be used to define the specific three-component data (RGB) being exchanged. However, the standard does not say what three-component data should be used nor does it provide profiles, etc. These are all user choices.

"Orchestrating colour is challenging because we have so many options and capabilities and there is no dominant solution providing a common direction."

The same application areas that are encouraging the exchange of three-component colour-managed data also seem to be increasingly accepting soft proofing on the colour monitor. Let's look at some of the issues (and potential pitfalls if not handled properly) involved in exchanging three-component colour-managed data based on soft proofing.

Display. The display profile (yes, in addition to being well-controlled and calibrated the display device must have a profile to convert data from the PCS to the display input values) must compress or clip data so that it will

ISO Steering committee for image technology (SCIT)

The current world of image technology covers a wide range of applications and industrial segments. As a result there is no one group or standards committee which has an overview of this area. In addition the field of image technology draws upon standards from many different areas and adapts them to their needs. This leads to fragmentation of standards development and redundant or overlapping work, largely due to lack of information rather than intentional duplication of effort.

A key issue is what is considered as imaging or image technology. A definition from a standards coordinating group in the 1980s is still as good as any. They defined an image as *"a representation or presentation giving a visual impression"* and image technology as *"any operations conducted on images that capture, synthesize, record, reproduce, convert, process, distribute, and display using photographic, electronic, computer or hybrid methods"*. This definition applies equally to the world of digital imaging today as it did to the world of analogue imaging then.

The ISO Steering Committee for Image Technology (SCIT) was formed in 2000 to continue within ISO the coordination work that had been started by ISO/IEC/JTAG 2, *Image technology*. Its purpose is to enable the sharing of information among those ISO technical committees involved in image technology, so as to better coordinate and manage activities. It does not assign or manage specific imaging standards projects. The intent is to identify new work as early as possible and to optimize the use of, and sharing of, resources for the development of standards in image technology.

The membership of the SCIT is open to all ISO/TCs and SCs (including those of ISO/IEC JTC 1) involved in image technology, and appropriate groups within any recognized international standardizing body (CIE, ITU, IEC, etc.). Membership is also offered to any broadly based group developing or using standards or specifications for image technology, contingent upon approval by the membership of the SCIT.

Further information : **www.iso.org/scit** fit the gamut of the display device. The typical monitor is approximately sRGB. Typically an intermediate work space will be a large gamut RGB (always larger than sRGB). Also, although most people do not realize it, the gamut of typical CMYK printing exceeds the gamut of sRGB in some parts of colour space. On top of all of that, appearance modelling must also be used to make a relatively dim self-luminous display "look" like a reflection print under high illumination.

The old term WYSIMOLWYG, *what you see is more or less what you get*, really applies to soft proofing. Yes, you can learn to compensate and estimate but it takes experience.

Profile Interchangeability. Although the format for ICC profiles is defined in the ICC Profile Specification (currently in ballot as DIS 15076), the transforms included in source and destination profiles are based on proprietary technology. Profiles from one vendor will NOT produce the same results as those from another vendor, nor should they be expected to. Some of those differences are what allow vendors to differentiate themselves. Different perceptual CMYK destination pro-files, even from the same vendor, may handle tone reproduction, gamut compression, and black generation significantly different. That is why PDF/X-3 says that the profile included as part of the data exchange should be used to render the data to CMYK. Too many people believe that if they decide to change output devices, they can simply substitute a new profile and get similar results. It doesn't work that way.

Even with colorimetric profiles, different colorimetric profiles should produce colorimetric values that are close to each other, but they all handle colours near the gamut limit differently. In addition, going from PCS to CMYK data, each vendor has unique colour separation and black generation algorithms – colour should be close but the components will be different.

(Courtesy IPA Bulletin)

Image Assembly. The issue of the assembly of multiple files using three-component colour-managed data has not been cleanly solved by the standards community or by the application vendors. We must associate a source profile or colour space definition with each object.

However, we cannot associate any other profile with individual objects. There is one destination profile that applies to the whole file. If we want to treat images differently within the same file, e.g., high key vs. low key tone reproduction in a destination profile, we cannot do that in a three-component colour-managed workflow. Further, if two files are prepared for the same characterized printing condition, but use different output profiles (or profiles from different vendors), they cannot be combined without additional processing. The caution in the PDF/X-3 application notes says, "If device-independent colour data is used in PDF/X-3 files, the profile included in the Output Intent of each file must be compared to those in all other files to be assembled together. Where all profiles are identical, the files may be assembled directly, retaining device independent colours. If different profiles are used, then colours must be transformed to the output device colour space prior to assembly to ensure that the correct gamut and tone compression is performed for each entity." Currently there are no other obvious solutions!

Black Channel Preservation. The classic colour management model says that to convert CMYK data from one device to another (where the gamuts are the same or close to each other), combining a colorimetric device to PCS transform for the first device with the colorimetric PCS to device transform for the second device, will yield the correct colorimetric results. And it will, except that the colour separation scheme and black printer will be what was included in the profile for the second device and may not bear any relationship to the initial CMYK. If this is for a non-halftone proofing device, it is probably more than acceptable. If the black-to-colour relationship is important, then some other transform is required – a number of applications have the ability to create black preserving device link transforms.

This is the classic problem that is faced by proofing systems and those systems that want to optimize CMYK data for a specific output device. Here the gamuts are correctly maintained by process control of solid ink density, but differences in tone value increase, trapping, etc., mean that different CMYK input is required for within gamut colours. Using the gravure process to match offset SWOP data is a perfect example of this situation.

Repurposing. Repurposing, not to be confused with retargeting, is sending output to a device with a different gamut than the gamut it was initially prepared for, for example, CMYK publication data to an internet web display. Retargeting is sending data to a device with the same gamut but different encoding. In repurposing, the first decision that must be made is whether the appearance in the initial output mode

About the author

David Q. McDowell is retired from the Professional Imaging Division of Eastman Kodak Company where he worked for 42 years. David McDowell is Chair of ISO Steering Committee for Image Technology (SCIT), Chair of the US Technical Advisory Group (USTAG) to ISO/TC 130, *Graphic technology,* Chair of TC 130/WG 2, *Prepress Data Exchange,* Chair of ISO/TC 42/JWG 21 Revision of ISO 5 *Densitometry Standards*, and Secretary of CIE Division 8, *Image Technology.* He was a key participant in the reactivation of ISO/TC 130, *Graphic Technology.*

Colour management

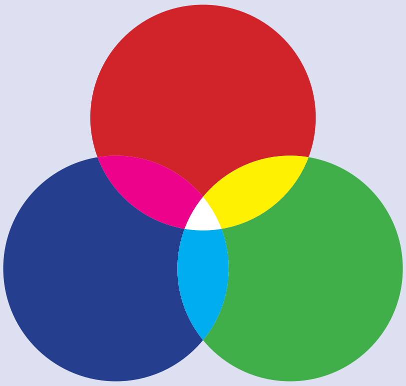
Colour management is the communication of the associated data required for unambiguous interpretation of colour content data, and application of colour data conversions as required to produce the intended reproductions. The colour content may consist of text, line art, graphics, and pictorial images, in raster or vector form, all of which may be colour managed. Colour management considers the characteristics of input and output devices in determining colour data conversions for these devices.

Colour management can be used to both communicate the colour that a creator requires on a destination device, and to allow the creator to get an accurate representation on the source device of the reproduction of the image on a selected destination device.

RGB vs. CMYK, or additive vs. subtractive colour

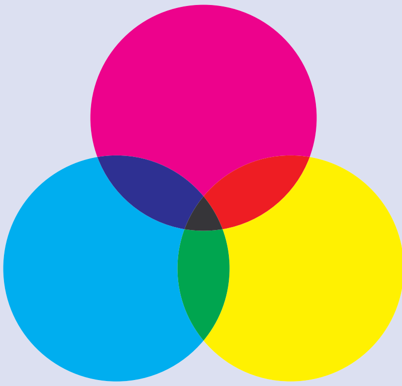
Additive colour synthesis creates colour by mixing various proportions of two or three distinct stimulus colours of light. Adding all colours from a light source together makes white. Sunlight (white light) splits into different colours when it passes through a prism. When light is absent, darkness (black) is the result. Using this system, colour mixtures may not be what you would expect. For instance, adding green to red makes yellow. Examples of where you find additive colour are:

- television and computer monitors;
- rainbows;
- light shows;
- fireworks;
- any light that comes directly to our eye from a light source.



Subtractive colour synthesis uses paints, dyes, inks, and natural colorants to create colour by absorbing some wavelengths of light and reflecting or transmitting others. With the subtractive colour process, white paper becomes darker as colours are mixed on it. Combining all colours in a palette on white paper will produce the colour black. Using this system, colour mixtures are what you would expect. For example, yellow and magenta make red. Examples of subtractive colour are:

- colour printing;
- photographic prints;
- most fine art excluding those pieces that contain light sources, such as neon sculpture;
- virtually any object that we see which doesn't produce light itself.



From IEC (International Electrotechnical Commission) Web site, **http://www.iec.ch/zone/colourmgmt/cm_whatis.htm**

(e.g., CMYK publication) should be preserved. If so, the output data must be colorimetrically converted back to PCS and then either a colorimetric or perceptual output profile used to convert to the new destination, depending on the relative size of the colour gamuts of the initial and new destinations. If the appearance in the initial output is not significant, then a new destination profile can be substituted, but the image should probably be reproofed for the new output condition to be sure the intent of the designer is preserved in the new output colour space.

Too often users believe that simply substituting a new destination profile without additional proofing or checking will produce comparable results on a different device. It is simply not that easy.

Where next?

Colour management does work and three-component data exchange can produce reliable results. There are limitations and cautions that must be observed.

Some have suggested that if all colour management systems did the same thing – used the same gamut compression, tone reproduction, etc – many of our problems would go away. Others have suggested that images should be gamut compressed and have tone reproduction corrections applied before being placed in a colour-managed workflow so that only colorimetric transforms would be required. These would allow much more commonality between applications but at the expense of flexibility and repurposing. This approach would make colour management a lowest common denominator system with few incentives for vendors to participate.

Today colour management gives us tools and capabilities that allow us to be more efficient and to do things that were impossible only a few years ago. Let's use what we have and be patient about today's limitations because they will be solved tomorrow. ■